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Metrics for measuring job creation by renewable energy technologies, using Ireland as a case study

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ABSTRACT

This report examines the metrics used to assess the job creation potential of renewable energy technologies (RET) industry to the economy, in particular the use of jobs/MW, and assesses the reliability of their use. Results were analysed on an individual country basis with particular emphasis on Ireland as a case study, and compared to other reports available in the literature.

The wind energy industry was the main focus of the study. Other RET industries examined were PV solar, wave, biogas and geothermal, as well conventional thermal industries. Data for the calculation of jobs/MW for wind quoted in this paper was taken from the 2008 EWEA [1] report “Wind at work: wind energy and job creation in the EU”.

The results of the study showed that use of jobs/MW installed in one year is an unreliable metric, as ratios are sensitive to installed MW in the year of the study. This paper suggests that jobs/cumulative MW may be a more reliable metric. Unfortunately the use of both metrics is common in the literature, and it is generally difficult to ascertain which metric type has been used or what method they used to derive the statistic. Furthermore, ill-defined classification of ‘direct’ and ‘indirect jobs’ and whether jobs quoted relate to national statistics or include export can lead to confusion and produce inaccurate and distorted country performance comparisons. Alternative metrics such as jobs/1000 head of population or MW/million head of population may be more reliable indicators. It is recommended that some form of standardisation needs to be created in the use of such terms for ease and reliability of analysis.

Contents

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1. Introduction

Aside from assisting to combat climate change and addressing the need for increased electricity generating capacity, the increased uptake of renewable energy technologies (RET) in recent years has also produced positive economic benefit through job creation. This report examines the key indicator, jobs/MW, which is commonly used to represent economic performance of RET. The metric's validity is assessed in this paper by cross comparing statistics for jobs statistics from other journal publications in Europe. Irish statistics are examined in more detail as a case study.

Review of the literature reveals large inconsistencies and lack of clarity in the statistics reported. New metrics are proposed in the conclusion of this paper which could provide clearer standards for providing statistics on the job creation potential of RET.

Wind is the most mature RET industry at present [2], and as such, forms the majority of the discussion for this report. Other RET, such as, solar photovoltaics (PV), biogas and wave are lesser contenders, but nevertheless provided a comparison to wind with regards performance of these indicators.

The majority of data analysis in this report is based on the 2008 EWEA [1] report "Wind at work: wind energy and job creation in the EU", which examined job creation from wind RET up to the year 2007. The graphs presented in the paper are aimed at displaying trends in installations in the various European countries. In order to facilitate this graphic illustration, units used in the *y*-axis of the figures had to be varied from graph to graph. Explanation of how the units are calculated is provided in the graphs and under each caption heading.

2. Background

The two methods examined in this report for assessing jobs created/MW installed are:

- Jobs/MW installed for one year.
- Jobs/cumulative MW installed.

Previous reports investigating jobs/MW have shown a wide variance in reported values, as represented in Table 1. Jobs/MW on average range from 10 to 16 jobs/MW for wind installed in any one year, and 1 to 4 jobs/MW for cumulative wind installed. It is noted that the many of reports fail to clarify if the 'jobs total' includes indirect jobs in their totals or if the MW total pertain to installed in one year or whether they are cumulative MW.

The definition of 'job' or job creation in relation to wind energy can be split into two categories: (a) direct jobs and (b) indirect jobs. According to EWEA definition [1], 'direct jobs' encompass the following areas of the wind energy industry:

- employment within wind turbine manufacturing companies and manufacturers, whose main activity is the supply of wind turbine components,
- wind energy project developers including installation, operation and maintenance,
- utilities selling electricity from wind energy,
- major research and development (R&D),
- engineering and specialised wind energy services.

'Indirect jobs' encompass the remaining areas of the industry, namely:

- intermediates or components from any other company,
- providing services,
- sporadic work in wind-related activities.

Confusion occurs with the exact definition of 'job'. Whilst 'direct jobs' often refer to manufacturing only, it can sometimes also include installation—especially where the figure quoted is jobs created per/MW installed (e.g. jobs/MW for a wind farm project will include installation). Further confusion also arises over the term 'long term' jobs, and is often quoted when referring to on-going operational and maintenance jobs [13]. Moreover, additional arbitrary indicators quoted in the literature include one-year jobs, one-man year jobs and manufacturing jobs per MW installed.

Lack of clarity also arises if one questions whether the jobs created are local only or have an export contingent. Jobs/MW is often used in reference to national statistics. Denmark is a typical example of where this not correct, as most of its manufacturing is aimed for export. Therefore a high jobs rate and a low local deployment, makes their jobs/MW statistic unrealistically high at 7.

Table 2 compares jobs/MW created by wind to other RET. Offshore wind studies have a large range of values, ranging from 3.9 to 47 jobs/MW. Reason for the variation is lack of clarity whether cumulative or non-cumulative statistics are used and possibly the newness of the industry. The solar photovoltaic (PV) industry has job rates ranging from 7 to 15 jobs/MW. Again, there is lack of clarity as to whether they refer to cumulative or non-cumulative installed figures, and whether they include indirect jobs. It is interesting to note that the EPRI report [14] states that installation jobs rates are 3 times that of manufacturing. The remaining industry sectors show job intensity results in the single figures, ranging from 1 to 5 for coal, gas, biogas and geothermal.

Although the wave energy industry is not yet fully established, there are three published reports which provide estimates for jobs generated by the industry. An Irish report [15] estimates potential creation of 1900 jobs per 200 MW of wave devices manufactured (depending on local or export estimations), which is approximately 9 jobs/MW and is a modest result in comparison to the wind industry just examined. A UK study [16] quotes "19 direct and indirect jobs/MW" at the start (unclear whether 19 is the total or for each job type), falling to 7 jobs/MW (not clear if this pertains to direct jobs only, or direct and indirect jobs) by 2020. Direct jobs in device and foundation supply are quoted at around 10 jobs/MW falling to 3.5 jobs/MW. Another UK study [17] quotes full-time jobs of 10 jobs/MW reducing to 4.6 jobs/MW by 2015.

Installation of RET can be highly labour intensive, depending on the location. The EWEA report 2003 for wind turbine installation [18] quotes installation at 6 jobs/MW, whereas their subsequent report in 2008 [1] dropped employment installation rate to 1.9 jobs/MW. In comparison, the report shows solar PV and wave have higher expected installation job rates of 7 and 10 jobs/MW respectively.

Employment related to operation and maintenance (O/M) will increase considerably as installed capacity increases, as it is cumulatively based. O/M for almost all RET varies between 0.5 and 2 jobs/MW. The greatest variation quoted was for wave at 9 jobs/MW [27] in the UK.

Table 1
Reports from Europe quoting jobs and the number of MW installed (cumulative or installed in one year, unless otherwise stated), which are categorised as jobs/MW installed in one year or jobs/MW cumulative, depending on the data source. The author has calculated the job/MW resultant in some of the cases.

Country	Report	Ref.	Year	MW power (cumulative unless otherwise stated)	Jobs created (proposed)	Jobs/MW installed one year	Jobs/MW cumul
Ireland	SEI	[3]	2004	225	100		0.44
	Finfacts[a]	[4]	2013	300 (non cumulative and offshore)	250	0.83	
	SEI[a]	[5]	2004	5 (non cumulative)	50	10	
			2004	215	138		0.6
UK	BWEA	[6]	2020	2,600	4,100		1.57
	BWEA	[7]	2006	7,000	5,000	11.7	0.71
	BWEA	[8]	2006	427 (non cumulative)	5,000	11.7	
	Bain	[9]	2020	27,000	36,000		1.3
Germany	Bain	[9]	2006	22,300	80,000		3.5
	Blanco	[10]	2008				1.71
Denmark	Bain	[9]	2006	3,100	21,600		6.9
	Blanco	[10]	2008				5.44
Spain	Bain	[9]	2006	14,700	31,500		2.1
	Blanco	[10]	2008				1.35
France	Blanco	[10]	2008				2.44
Europe	SEI	[5]	2008	50,000	32,000		0.64
	Future Energy	[11]	2020	180,000	368,000		2
World	UNEP	[12]	2010			16	0.43–2.51
			2030			11	

[a] Wind farm installation project.

Table 2
Comparison of jobs/MW of varying sectors of the wind energy industry in comparison to other energy sectors.

			Direct Jobs/MW-one year	Installation jobs/MW	O/M jobs/MW
Wind	[a]	Ireland	25		
	[18]	Europe 2003	12[b]	6	0.23
	[1]	Europe 2007	9.5–15 (0.4 cumulative)	1.2	0.1–0.33
	[19]	California	2.6[b]		0.3
Offshore wind	[20]	Italy	43–47[b]		1.2
	[21]	Denmark/USA	17[b]		5
	[22]	USA	480 MW/1881 jobs[c] = 3.9	0.5	0.15
Geo	[19]	California	4[b]		1.7
Solar	[19]	California	7.1[b]		.1
	[23]	Europe	10–15[b]		1
	[14]	EPIA	10[b]	30	1
	[24]	USA	15[b]	7	
Bio	[19]	California	3.5[b]		2.3
Gas	[19]	California	1[b]		1
Coal	[25]	Nevada	1.01		
	[26]	USA	2.5 construction 0.72 long term		
Wave (predicted)	[15]	Ireland	1900 jobs/200 MW[d] = 9.5		
	[27]	UK	19[c]	10	9
	[17]	UK	10		

[a] Is a summary data taken from Fig. 7.
[b] No reference in the document as to whether MW refers to cumulative or per year.
[c] Includes indirect jobs.
[d] Cumulative total. Cumul = cumulative.

Table 3
List of European countries studied in this report, listing 2007 statistics for population [28], MW installed [8] and direct jobs created [1].

Country	Population 2007 (millions)	MW installed 2007	Direct Jobs created 2007
Ireland	4.5	59	1,500
Finland	5.2	24	800
Denmark	5.4	3	23,500
Bulgaria	7.6	34	100
Austria	8.2	20	700
Sweden	9.1	217	2,000
Hungary	10	4	100
Czech	10.3	63	100
Belgium	10.5	93	2,000
Portugal	10.6	434	800
Greece	11.1	125	1,800
Netherlands	16.3	210	2,000
Poland	38.1	123	800
Spain	44.4	3522	20,500
Italy	59	603	2,500
UK	60.8	427	4,000
France	63.4	888	7,000
Germany	82.3	1667	38,000
Total	456.8	8516	108,600

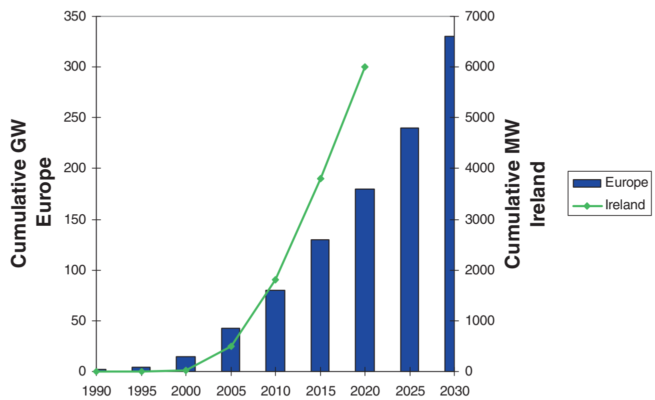


Fig. 1. Installed wind power in Europe until end 2007 and projected capacity until 2030 [1]. Cumulative installed wind power in Ireland up until 2008 [29] and projected capacity until 2020 [32].

3. Data used in the analysis

Statistics used in this report are displayed in Table 3.

- Population of the country. Data used was from the 2007 Eurostat report [28].
- MW installed in that year (2007 for this study). Data used was from the 2007 EWEA report [8].
- Direct jobs created by wind industry in 2007 [1].

4. Total MW and MW/head of population

4.1. European wind capacity

The cumulative total wind energy installed in Europe by 2007 was 56 GW, and is projected to expand 4-fold to 180 GW by 2020 and 330 GW by 2030 [1] (Fig. 1). A total of 8.5 GW of wind was installed in Europe in year 2007 [8]. Spain, Germany, topped the installation list in year 2007, with 3.6 GW and 1.6 GW respectively installed that year (Fig. 2). Ireland's installed capacity for year 2007 was small (59 MW) due to a moratorium on installation.

Germany and Spain also top the cumulative MW installed by 2007, with 22 GW and 16 GW respectively (Fig. 2). Ireland, in 2007, had a cumulative wind capacity of 0.8 GW (Fig. 1) [29]. 2007 was a quiet year with only 59 MW of installations [8], due to a moratorium on wind planning applications as a result of grid connection and grid infrastructure problems. However, in 2008, installations of round 2 applications commenced and over 200 MW were added to the system that year, bringing the total installed capacity to 1 GW [30]. The large increase in between the two years highlights the ephemeral nature of capacity statistics influenced by factors such as legislative changes to subsidies and tariffs, as well as market forces. Grid infrastructure upgrading is currently being addressed by the Grid 25 plan, which proposes € 25 M in grid reinforcement to cater for the larger projected capacity of wind energy [31]. Ireland has ambitious plans for a 5-fold increase in installed wind energy capacity on the island, with intentions to install a total of 5.3 GW by 2020 [32]. The extra 4.3 GW are planned in two stages: gate 2 comprising 1.3 GW of onshore wind from already approved offers, and gate 3 comprising 3.9 GW of commissioned offers consisting of 3.12 GW onshore wind [33] and 0.78 GW of offshore wind [34].

4.2. MW/per head of population—one year

MW installed per head of population in millions (MW/million head) is calculated as follows in Eq. (1):

$$\text{E.g. Finland}\ \frac{24\,\text{MW}}{5.2\,\text{million population}} = 4.6\,\text{MW/million head} \qquad (1)$$

From Fig. 3, it is observed that Spain and Portugal had the highest installation rate with 80 and 40 MW/million head respectively. Ireland recorded 13 MW/million head. Due to policy changes in Denmark, only 3 MW of wind was installed in 2007, resulting in a low 0.6 MW/million head (M). The European average was 18.6 MW/million head

4.3. Cumulative MW/per head population

The use of cumulative MW installed up to the year of the study in calculating MW/head pop may provide more insightful ranking system than the use of MW installed in one year. The average cumulative wind energy capacity in the 17 countries sampled in Europe per head of population was 122 MW/million head in 2007.[1] Germany and Spain retain their high ranking positions on the list with 341 MW/million head and 270 MW/million head respectively (Fig. 4). However countries with smaller populations such as Denmark, Portugal and Ireland rise to 1st, 4th and 5th in the European rankings.

5. Jobs created

Whilst total capacity of installed wind RET provides an interesting statistic from the point of view of benefit to total green house gas abatement, it gives little direct insight with regards relative employment benefits for an economy. Analysis of the jobs created by an industry is important as this factor is commonly used as a gauge of the economic return to society. Job intensity required in the wind RET industry is generally quoted as greater than that in other RET sectors [35], and is evident by the data presented in Table 2. Over the past five years, the EU wind energy industry has created a total of more than 60,000 new jobs, or on average, 33 new jobs every day [36]. The EU wind energy sector directly employed approximately 108,600 people in 2007 [1]. Including indirect employment, the wind energy sector employed 154,000 in the EU (Fig. 5). A previous EU-15 survey found that wind energy directly employed 48,363 people in 2002 [37], demonstrating that direct employment has actually increased by 60,237 (125%) since then. Consequently, given current trends, total job employment in the wind industry is forecast to double to 330,000 by 2020 and 375,000 by 2030, with the vast majority of the jobs derived from offshore wind (Fig. 5) [1].

The amount of (direct) jobs created in each of the 17 countries are listed in Table 3. Germany had the highest job creation figure in Europe at 38,000 jobs, followed by Denmark, Spain, UK, France and Italy respectively.

5.1. Jobs per 1000 head population

The number of (direct) jobs created directly per head of population is examined in Fig. 6. Jobs assessed were those in existence in the year 2007.

[1] In 2007, total cumulative GW installed in the 17 countries selected for the paper was 56,000 MW and population was 456 million. 122 MW/head (M) was calculated as follows: 56, 000/456.

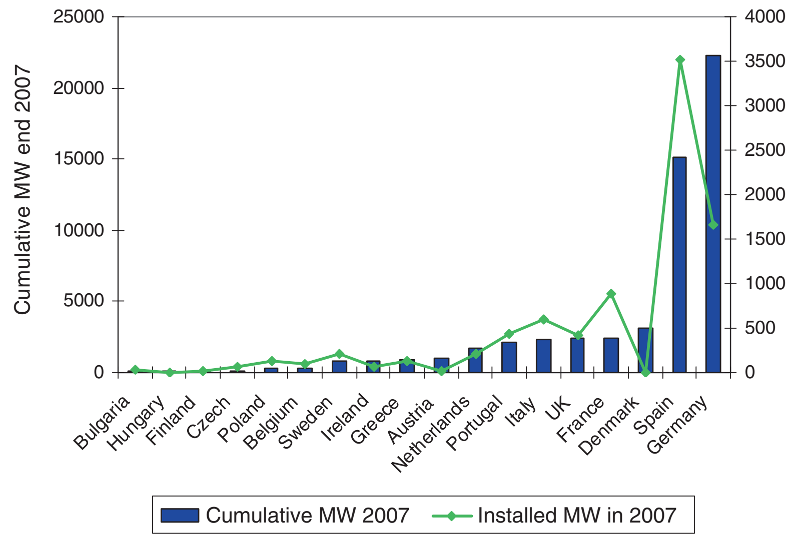


Fig. 2. Graph of cumulative wind capacity installed by end 2007 and actual installed capacity in 2007 only [8].

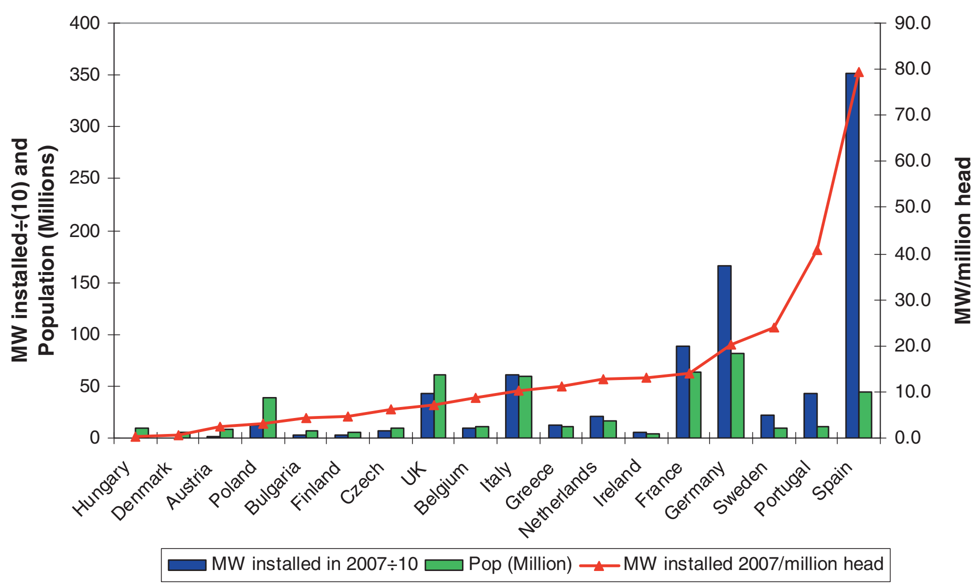


Fig. 3. Population (millions) [28] versus MW installed (divided by 10 for better graphic illustration) [8] in 2007, as well as MW per head of population. For example Ireland had 59 MW installed, and was scaled down by a factor of 10 = 5.9. For the right *y*-axix, MW/million head = 59 MW/4.5 million head = 13.1. Graph goes from left to right in ascending order of MW/head of population installed.

The statistic used in this section is jobs/1000 head is calculated as follows in Eq. (2):

$$\text{E.g. Finland}\,\frac{800\,\text{jobs}}{5.2\,\text{million people}/1000} = 0.15\,\text{jobs}/1000\,\text{head} \qquad (2)$$

Denmark had the greatest ratio at 4.5 jobs/1000 head, whereas the European average was an order of magnitude lower at 0.15 jobs/1000 head. Germany, Spain and Ireland respectively had the next highest ratio with an average of 0.5 jobs/1000 head, with the remaining of countries sampled an order of magnitude lower again.

5.2. *Jobs created per MW wind*

Jobs/MW is the most common method of assessing the economic potential of RET. It is derived by Eq. (3):

$$\text{E.g. Finland}\,\frac{800\,\text{direct jobs}}{24\,\text{MW installed in 2007}} = 33\,\text{jobs/MW} \qquad (3)$$

Data from the EWEA report on direct jobs created in year 2007 [1] and MW installed are listed in Table 3, with results shown in Fig. 7.

5.2.1. *Jobs/MW installed in one year (2007)*

Using EWEA data, 13 jobs/MW direct jobs were created in Europe in year 2007 (direct + indirect jobs/MW = 17.7 jobs/MW[2]) [1]. The EWEA, in a 2003 report [37], shows that between 15 and 19 jobs were created per MW installed, however the report fails to specify if the figures pertained to direct or indirect jobs. Similar job intensities were quoted by United Nations Environment Programme (UNEP) [12] at 16 jobs/MW (turbine manufacture and supply of components).

[2] This figure varies from the EWEA [1] report of 15.1 jobs/MW, implying that its figures for 2007 installed capacity is different (close to 10,000 MW installed would be required). The EWEA report fails to mention the source of its installed MW data or the total MW used in its calculations.

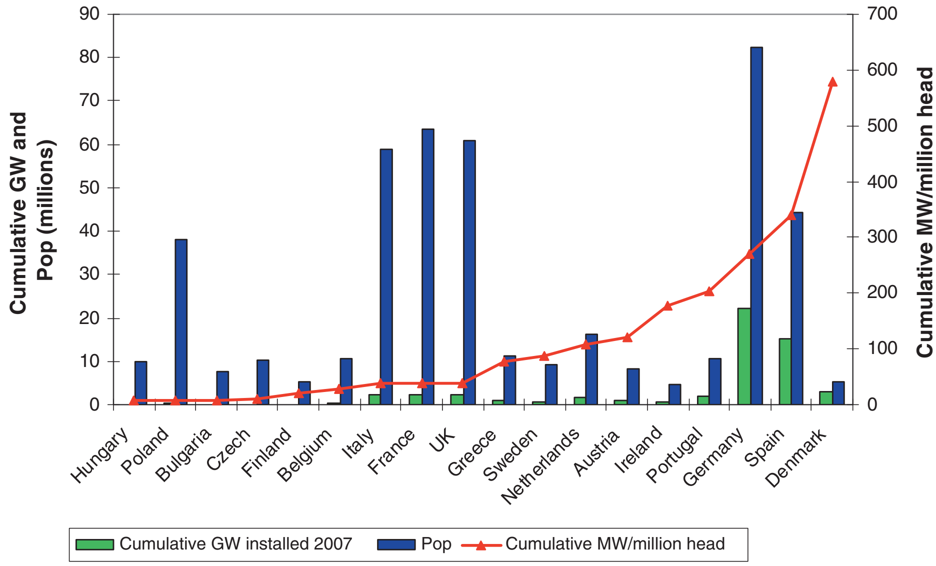


Fig. 4. Population [28] and cumulative GW installed [8] wind by 2007 on the left *y*-axis. On the right *y*-axis, MW are used instead of GW. Graph goes from left to right in ascending order of cumulative MW per head population (Ireland result of 177 for cumulative MW/million head pop = 796 MW/4.5 million pop).

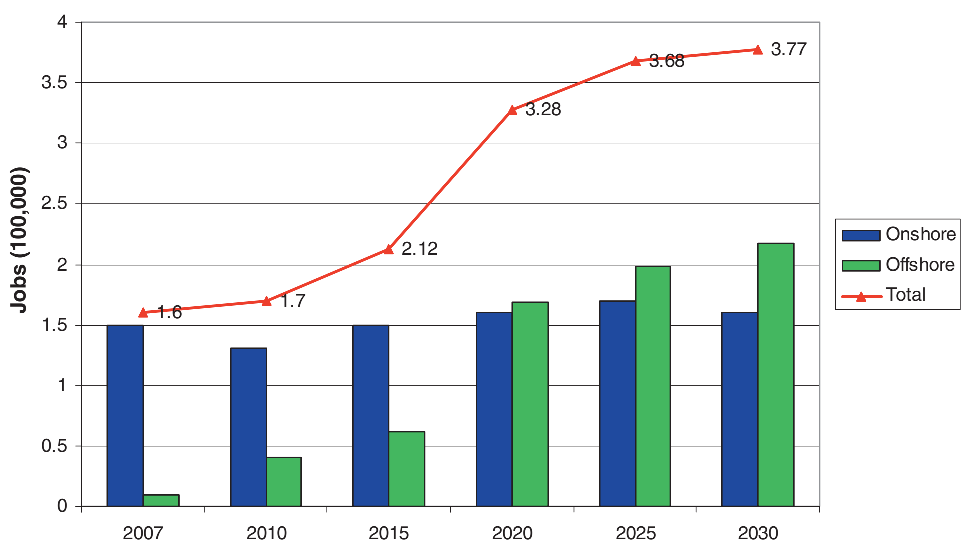


Fig. 5. Jobs created by wind energy industry (onshore and offshore) in Europe in 2007 and projected to 2030 [1].

From an individual country perspective, jobs/MW in one year statistic varies substantially and can be difficult to interpret following unusual variations in installed capacity in year 2007 (government policy changes in that year resulted in unusually low installations rates by Ireland and Denmark).

Germany was the only country with a high capacity installation in year 2007 and also recorded over 20 jobs created/MW (Fig. 7). In comparison, Portugal, France and Spain also recorded high installed capacity in year 2007 however their average jobs/MW were much lower than Germany, ranging between 2 and 10 jobs/MW. This result is confusing considering countries such as Spain have a very strong wind manufacturing industry. Smaller populated countries such as Ireland, Finland, Austria and Belgium recorded much higher jobs/MW ratios (e.g. Ireland of 25 jobs/MW installed in year 2007). Since these smaller populated countries have no indigenous wind manufacturing industries, the result implies any such job creation must result predominantly from the installation process. The high ratios could possibly be due to more labour required for wind installation in those particular countries. However, the result also causes some doubt as to the validity of the figures especially for Ireland.

Denmark showed a result of 7833 jobs/MW for year 2007. This resulted from an unusually low installation level of 3 MW for the year 2007, whilst having a very strong manufacturing industry, which distorted the ratio dramatically.

It is considered, these anomalies cause doubt as to the validity of the indicator.

5.2.2. *Jobs/MW cumulative*

Many reports utilise cumulative MW data in their jobs/MW estimations (refer to Table 1). Results using cumulative MW data from Table 3 are displayed in Fig. 8

Denmark remains at the top of the list with 7.5 jobs/MW. However, the order of merit changes for the remainder of the countries, with Germany and Spain slipping down the ranks by an average of 2 jobs/MW. Ireland slipped substantially lower in the sample from near the top of the list in Fig. 7 to midway with 1.9 jobs/MW in Fig. 8. On the other hand, smaller countries, such as Belgium and Finland, moved closer to the top returning similar statistic results to Denmark of 6 jobs/MW. Average jobs/cumulative MW over the total sample was approximately 1.9.

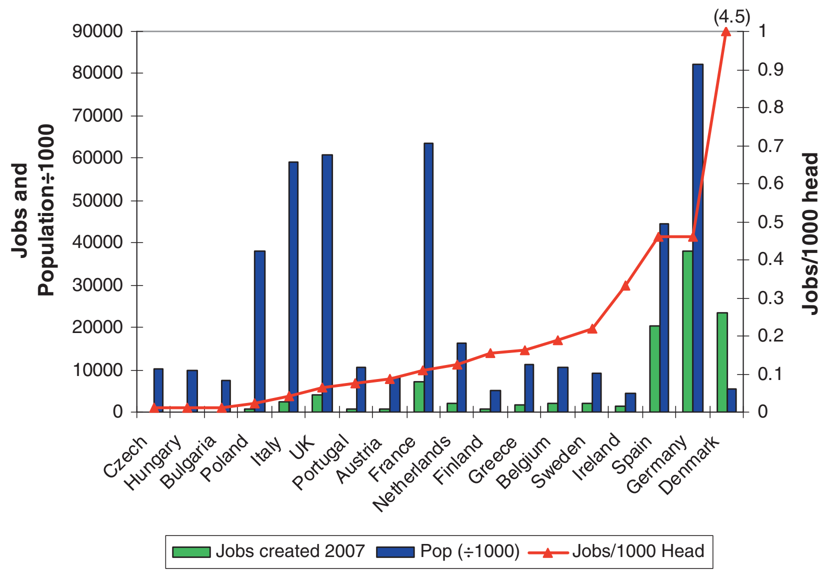


Fig. 6. Number of direct jobs involved in the wind industry in Europe 2007 [1], the population of each country (÷1000) [28], and the jobs per 1000 head of population. Graph goes from left to right in ascending order of jobs/head pop. Jobs/1000 head pop value for Denmark was off the scale of the graph at 4.5.

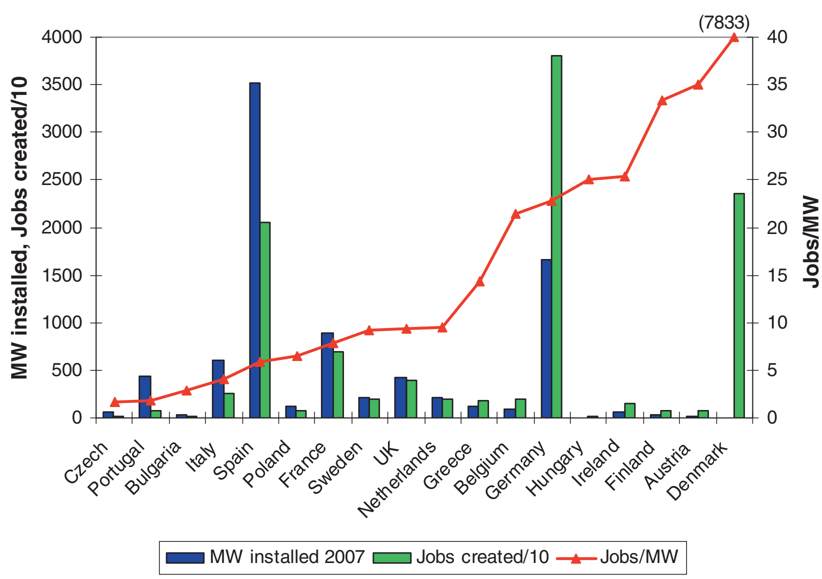


Fig. 7. On the left *y*-axis, the total capacity installed (MW) in 2007 only [8] and direct jobs created in Europe in 2007 [1] (for graphic clarity jobs were divided by 10). On the right *y*-axis, jobs/MW. Graph goes from left to right in ascending order of jobs/MW created. Jobs/MW for Denmark total was outside the scale of the graph at 7388 jobs/MW.

6. Jobs created by installation, operation and maintenance of wind

The most obvious potential job gain exists in the manufacturing of wind turbines. However, the industry also creates employment in system design, installation and maintenance, research and development, education and training, energy auditing and management, and consulting. The term "direct employment" contains these industry sectors as well as the more obvious candidates of manufacturing. Analysis of the proportion allocated to each part of the industry was carried out by EWEA [1] and represented in Fig. 9.

6.1. Installation

EWEA [1] quoted 1.2 jobs/MW (annual) for installation, although the previous EWEA report 2003 [18] for installation quotes 6 jobs/MW. An NREL [38] study reports similar findings for windfarm projects of 0.07–1.57 jobs/MW for 1-year construction (i.e. installation) (Table 4). Unfortunately, there does not appear to be a correlation between jobs/MW and farm size e.g. 3640 MW needed 7.4 jobs/MW. A Danish study stated that installation took 5 people per MW [39].

6.2. Operation and maintenance

UNEP, EWEA, NREL and 2 other reports estimate that operation and maintenance requirements will contribute between 0.1 and 0.33 jobs for every MW of cumulative capacity [1,12,13,38,40,41]. The Australian Centre for renewable energy estimated that 1.2 jobs/MW would be created, but falls at 9% annually to 0.06 jobs/MW for installations in 2010—an overall 50% reduction [42].

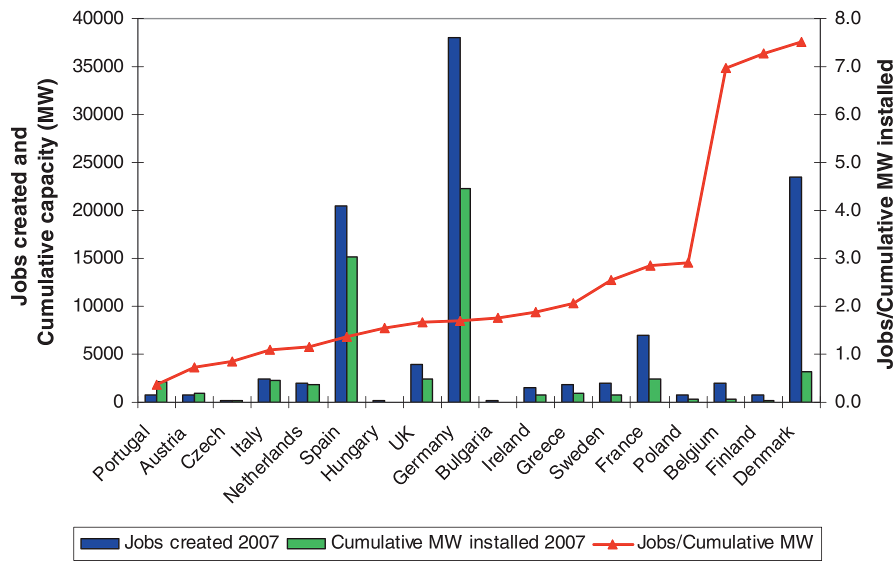


Fig. 8. Jobs (direct only) created in Europe in 2007 [1], the cumulative capacity installed up to end 2007 (MW) [8] and resultant jobs/MW. Graph goes from left to right in ascending order of jobs/MW created.

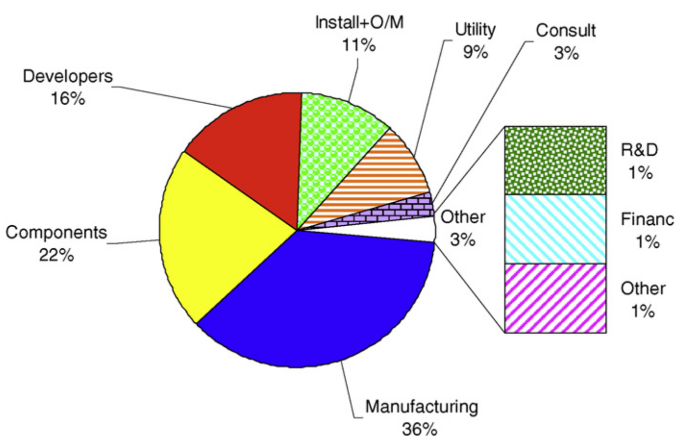


Fig. 9. Percentage of employment created by each sector of the wind energy industry in Europe [1].

7. Inconsistencies with present metrics used

Data research for this report identified a number of inconsistencies in relation the manner data is categorised and reported. The following data categories necessitate that researchers exercise caution to avoid confusion of statistics:

- Installed wind capacity: data is presented either as MW installed for one year, or cumulative MW installed till the end date of the study. Care must be exercised in distinguishing which particular category of data is used.
- Jobs created: the definition of this term is arbitrary:
  - Direct jobs—may exclusively refer to jobs pertaining to manufacturing of the turbine only, or may refer to all jobs pertaining to the final creation of a wind turbine, including installation, O/M, finance, legal as well as manufacturing.
  - Indirect jobs—usually refers to other industries that benefit from existence of wind energy sector, for example accommodation, roads, etc. However, indirect jobs may also sometimes refer to indirect manufacturing, which includes manufacturing of all components of a turbine e.g. ball bearing generators, etc. Components made outside the main fabrication factory of the RET may be grouped at times in either 'direct jobs' or 'indirect jobs' categories.
  - Local or export jobs—countries like Denmark with large export of turbines and low national deployment will have disproportionally large jobs/MW statistics.

8. Summary of findings

When viewed from 'per head of population perspective' and MW installed for year 2007 only, Ireland recorded 13 MW/head (million (M)), lower than the European average 19 MW/million head (Table 5). This was due to an unusually low installation rate for Ireland in 2007. When viewed from a cumulative MW perspective, the Irish result was higher than the European average with 177 MW/million head compared to the Europe average of 122 MW/million head.

Table 4
NREL report listing wind project installations in the USA, and estimated job creation per MW [38].

Project	Project size MW	Installation Jobs/MW	O/M jobs/MW
Wind farm 1	4100	1.57	0.31
Wind farm 2	3700	5.8	0.2
Wind farm 3	3640	7.4	0.6
Wind farm 4	1800	0.7	0.14
Wind farm 5	1700	5.12	0.35
Wind farm 6	390	0.48	0.15
Wind farm 7	107	0.07	0.3
Wind farm 8	50	0.51	0.45
Wind farm 9	30	0.87	0.36
Wind farm 10	25	0.16	0.24

Table 5
Summary table of Irish and European statistics for wind capacity/head of population and jobs created per head of population and per MW.

		2007 only MW installed	Cumulative MW 2007
Wind installed/head population (millions)	Ireland	177 MW/million head	13 MW/million head
	Europe	122 MW/million head	14.6 MW/million head
Jobs created/head population	Ireland		0.33 jobs/1000 head
	Europe		0.15 jobs/1000 head
Jobs created/MW installed in 2007	Ireland	25	1.9 jobs/MW
	Europe	13	1.9 jobs/MW

Potential job creation was analysed by two methods. The first was jobs created per head population (/1000), where the average for Europe was 0.15, whilst Ireland had double that figure.

The second method was by analysing job creation by MW capacity installed (i.e. direct jobs: manufacturing and installation + O/M). In Europe, a total of 13 jobs (direct jobs) were created on average for capacity installed in year 2007 only. Ireland's figure was double that at 25 jobs per MW installed (direct jobs). However, if using cumulative MW in the estimations, both Ireland and Europe averaged 1.9 jobs/MW (direct jobs).

Comparison of wind energy jobs/MW to other RET, from Table 2, is difficult as a problem arises as to whether the figures used pertain to MW installed in one year, or total cumulative MW, as well as whether direct or indirect jobs are used. The majority of reports in Table 2 use cumulative MW in their estimations.

Whilst the PV industry is generally recognised as labour intensive, the data shows jobs/MW figures quoted in Table 2 are on par to wind energy jobs/MW installed in year 2007 for Europe. Jobs/MW for wind are also comparable to those predicted for wave energy. Job intensity increases when wind is taken offshore, with Danish reports quoting 17 jobs/MW, together with a high long-term job expectancy of 5 jobs/MW in operation and maintenance. Jobs/MW for conventional thermal energy are much lower at around 1 job/MW.

Installation job rates for many RET can be as labour intensive as fabrication. The European Photovoltaic Industry Association (EPIA) quotes that more jobs are created in the installation and servicing of PV systems than in their manufacture [14] (30 jobs/MW). This figure contrasts dramatically to the wind energy installation job/MW figure quoted by the EWEA; 9 jobs/MW in their 2004 report [18], and 1.2 jobs/MW in their 2008 report [1]. Wave, which is predicted be very labour intensive in its installation, is predicting 10 jobs/MW.

Given the possibility that Ireland may never succeed in establishing a renewable energy manufacturing industry, job creation may be reliant on installation, operation and maintenance services. As Ireland currently has no indigenous manufacturing industry, all employment must be derived from installation and O/M. Jobs/MW figures estimated in this study for Ireland (as just mentioned by default relating to installation and O/M) were 22 jobs/MW installed in one year (2007) and 1.9 using cumulative MW. The 22 jobs/MW figure is very high if compared to the average European installation statistic of 1.2 jobs/MW quoted in the EWEA 2008 [1]. Thus, it may appear that the use of jobs/cumulative MW could be the more accurate metric to use in Ireland as it mirrors the average installation rate of 1.2 jobs/MW calculated for Europe. The majority of studies in Table 2 also use the metric jobs/cumulative MW installed, although they fail to flag their method in the text. It could be argued that the figure quoted in the EWEA 2008 [1] report is much too low.

O/M jobs will provide the long term jobs types for the industry. And wind, due its low ongoing maintenance requirements has the lowest employment rate at 0.1–0.3, along with solar. Other RET industries will require much higher ongoing employment rates, at approximately 2 jobs/MW (Table 2).

9. Discussion

Two methods of estimating the job creation potential of wind were investigated: per head population and per MW. The use of jobs/MW is the most frequently used metric in the literature, however the majority of these reports fail to clearly define which methodology they have used to derive the statistic (cumulative or non-cumulative (one year)). Jobs/MW (installed in year of study) is overly sensitive to annual variations in MW installed, often dictated by economic climate and government policy. Rather, the method based on jobs created per cumulative MW could be a more stable performance indicator as each quantity has less variation over a year to year basis, and is the metric used in the majority of reports reviewed in the literature review section of this paper. However, this method cannot be tested for validity at present until the EWEA publish their next report on job creation, which is due shortly in 2011.

Jobs/MW rates for countries which are exclusively installation based, such as Ireland, can be as high, or often higher than countries which have both manufacturing and installation, such as Spain and Germany. Thus it could be inferred that countries exclusively focused on installation can produce more jobs/MW than those that have a manufacturing base as well. It is advised that direct jobs be separated into its components of manufacturing, installation and O/M when referring to jobs in jobs/MW metric for greater clarity.

Lack of clarity also arises if one questions whether the jobs created and jobs/MW statistics relate to locally deployed MW (and imply a national statistic) or include export. Denmark is a typical case, where a high wind turbine export industry results in a large jobs statistic. However, if combined with their current low national deployment MW rate, produces an unrealistically high jobs/MW statistic.

Further ambiguity occurs when referring to Jobs/MW from wind farms and comparing them to national statistics. Jobs related to wind farm construction imply installation jobs. The high jobs/MW in one year statistic for Ireland, which is exclusively installation based, should be comparable to jobs/MW installation rates for a wind farm project, which the present study shows is not the case. Moreover, most wind farm installations jobs/MW rates quoted are much lower than national statistics for jobs/MW installed in 1 year, not higher. O/M is also often included in installation job rates and further contributes to inaccuracies, since O/M uses cumulative MW which increases according to increased installation capacity. The use of the term “manufacturing jobs per MW installed” adds further confusion, as it is not clear whether the term is exclusive to manufacturing or combines installation jobs with manufacturing. It is advised that quoting jobs/MW for wind farm projects be kept separate from national statistics quoting jobs/MW.

The definition of ‘direct and indirect jobs’ can also be arbitrary and potentially creates confusion in analysis of statistics. Direct jobs may refer exclusively to the direct manufacture of turbines, or alternatively may refer to the entire industry involved in the final creation of the turbine including installation and O/M. Conversely, indirect jobs may refer to all industry not directly involved in the manufacture of the turbine (i.e. ball bearings and installation) or

alternatively may refer to job creation completely divorced from wind turbines, but created as a result of the wind turbine industry. Further confusion also arises when some reports use job-years/MW and one-year jobs.

10. Conclusion

In conclusion, great care needs to be exercised in interpreting statistics related to the area of job creation potential from RET, especially with the use of the metric jobs/MW. Similar reservations are quoted by Blanco and Rodrigues [10] in their 2008 study. It is considered that some form of standardisation of the metrics is required for ease of comparison and accuracy of analysis. Metrics used to quote job performance in reports should have their methodology clearly explained to avoid misinterpreting their results, especially in the definition of 'job' (direct or indirect), MW (installed in one year or cumulative) and whether jobs include export capacity. Alternative metrics stemming from this paper for measuring jobs potential of RET are cumulative MW/head of population, direct jobs/1000 head of population or direct jobs/cumulative MW installed (jobs/MW installed in one year is not recommended). However, none are ideal and all need definition when quoted. Care should be exercised when comparing jobs/MW for national statistics where countries have a large export contingent, as well as comparing those rates to individual wind farm development projects.

Finally, jobs/MW potential from RET industry is potentially large, especially from wind, solar and wave, both in fabrication as well as installation and O/M. However, it could be argued that there is a lack of benefit of producing a product involving high jobs/MW and low energy output, when compared to conventional thermal energy. Other important benefits such as security of supply and climate change mitigation need to be considered simultaneously as job creation gain.

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